SUGGESTIONS TOWARD A LABORATORY COURSE IN COMPARATIVE PSYCHOLOGY.

By Linus W. Kline, Ph. D.

"In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale."—*C. Lloyd Morgan.*

"But why should we bind ourselves by a hard and fast rule. . . ? Is it not the truth at which we wish to get? For myself, I am becoming more and more skeptical as to the validity of simple explanations for the manifestation of animal life whether physical or psychical."—*Wesley Mills.*

The following experiments in comparative psychology were devised to fill a small part of the work offered at Clark University in the Psychological Practicum.[1]

I have been guided by two principles in selecting animals for experimentation: (1) general distribution of the species; (2) an animal little influenced by captivity and permitting a variety of experiments of a psychological value.

The animals thus selected are regarded as typal, *e. g.*, earth worms of vermes, slugs of mollusca. A careful study of the instincts, dominant traits and habits of an animal as expressed in its free life—in brief its natural history should precede as far as possible any experimental study. Procedure in the latter case, *i. e.*, by the experimental method, must of necessity be largely controlled by the knowledge gained through the former, *i. e.*, by the natural method. In setting any task for an animal to learn and perform, two questions should be asked: (1) Does it appeal to some strong instinct? (2) Is it adapted to the animal's range of customary activities?

The adage, "Make haste slowly," is highly applicable to the present field of scientific work, not only in working with the animals, the manual execution, but especially in the matter of drawing inferences and interpreting the facts.

The work as a whole, on account of its newness, must be regarded as tentative. And notwithstanding the fact that the problems and experiments here outlined have been largely

[1]Experiments on Arthropoda (daphnia, crayfish, bees, ants, and wasps), Amphibia (frog, newt), Reptilia (lizard, turtle), and Canidae (dog) are omitted from this paper for the reason that many of them are yet untested or are in the process of making.

selected from the works of the foremost scientists in their respective fields, and further that I have retested their "workableness" in many cases from the standpoint of psychology, they still belong to the suggestive stage and must remain such until they are extensively tested—not merely discussed—by student and teacher in a number of laboratories.

The literature given here, although by no means exhaustive, contains in every case matter pertinent to the subject. The aim is to acquaint the learner with a few of the best works in the field, leaving the minor ones to his own industry.

The hope that the present outline will awaken a wider interest and enlist a larger co-operation in testing the value of the methods here set forth is my only justification for presenting this paper.

The nature of this work has necessarily put me under obligations to many persons.

For the greater part of the material itself I am indebted to those from whose works I have drawn and to whom I make acknowledgments in the references accompanying the experiments. For the original plan of the work, and for seeing that ample laboratory material was provided me, together with much assistance in the arrangement of the subject matter of this paper, I make grateful acknowledgments to Dr. Edmund C. Sanford.

I am thankful to President Hall for the loan of books from his library, and for the inspiration received from his hearty approval of the work itself.

To Dr. C. B. Davenport, of Harvard University, I feel greatly indebted, not only for the several experiments selected from his published works, and citations to literature, but also for personal suggestions and his keen interest in the purposes of the work.

AMOEBA.

The chief psychological interest in Amoeba is the variety of activities that it is able to perform with an apparently undifferentiated structure. It feeds, it gets rid of waste material, it reacts to stimuli, it moves from place to place, and it reproduces by division.

The student should observe carefully to what stimuli it appears responsive, and especially any cases of apparent selective activity in the taking of food, and in the latter case should consider whether or not the act in question requires a psychical explanation.

Probably[1] the simplest and surest method of securing Amoeba

[1] Behla, Robert: Die Amöben, inbesondere von Parasitären und culturellen Standpunkt. Berlin, 1898.

This excellent little monograph, besides containing a bibliography

is from green grasses taken from streams and ponds. Put a small handful of such green material in a large evaporating dish, and barely cover it with tap water. Amoeba may be found at once. I get better results by waiting three or four weeks, replacing in the meantime the evaporated water.

Such material answers every purpose for observing the life processes of the Amoeba. By permitting the glass slide to dry up by evaporation Amoeba's reaction to desiccation may be observed.

It is convenient[1] to rest the four corners of the cover slip on small bits of glass of uniform thickness cemented together, or better still on four wax feet which admit, by pressure, of regulating the space between cover slip and slide—say 1½ mm. apart.

VORTICELLA.

The qualities of this infusoria that lead to its selection for study here are: first the easy observation of the same individual for a considerable period of time, due to its permanent attachment; second, the variety and clear cut character of its activities and the fact that they are performed in a comparatively short cycle; and third, the fundamental and suggestive character of these activities, viz.: contraction of stalk, movements of cilia, food-taking, reproduction, etc.

Place in a medium size glass jar a bunch of grass blades gathered from a running stream, or pond; cover with water. Vorticella may be found in abundance on the decaying grass within a week or ten days. They will "hold their own" in the

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and descriptive account of Amoeba in the interests of medicine, treats historically of the many attempts to obtain a pure culture of Amoeba. No one method is as yet satisfactory. Dr. Behla, himself, recommends the following: 25 grs. of flaxseed stalks, placed in a liter of water 48 hours. Filter, and to the filtrate add a 1% solution of agar and sodium carbonate until the solution becomes alkaline. *Amoeba Spinosa* develops in large quantities. Ogata, according to Behla, put into a large evaporating dish, partly filled with water, green grass taken from an open canal. It proved to contain Amoeba and Infusoria. He put a few drops of this water into a test tube, which was filled with the following nourishing solution kept in a sterilized vessel: a filtered solution of 50cc of tap water containing 2.5% grape sugar. To separate the infusoria from the bacteria he dipped into the the test tube capillary tubes 10-20 cm. long and 0.4-0.6 mm. in diameter filling them with the culture medium. Sealed the ends in a flame. The entire length of the tube was examined under a microscope and the region exceptionally plentiful in Amoeba, and freed from other forms, was marked and broken off.

[1] Those who may desire to study Amoeba's reactions to a single stimulus, *e. g.*, light, temperature or chemical, should consult Verworn's Psycho-Physiologische Protisten-Studien, Jena, 1889; J. Loeb's Der Heliotropismus der Thiere, pp. 118, Würzburg, 1890; and Davenport's Experimental Morphology, Vol. I, pp. 155–218.

aquarium for several weeks, after which they succumb to other forms.

Their form[1] and structure[2] are described in manuals of zoölogy.

Select one in a quiescent state, and by using magnification from 375 to 425 diameters, draw the following structures: calyx (the bell shaped body), the peristomal lip or lid to the calyx; the stalk, and ribbon like contractile tissue (draw these contracted and extended), the contractile vesicle and band like nucleus.

Activities. I. Vegetative. Do you discover any rhythm in the contraction of the vesicle? Does the stalk contract when the calyx and cilia[3] come in contact with any rigid, resisting, unmanageable object, or is it indifferent to some, while it avoids others;—*i. e.*, does it seem to distinguish between harmful and harmless objects?

Put Vorticella in a continuous current of distilled water brought from a reservoir by means of a glass syphon, drawn to a capillary point, placed at one side of the cover-slip and a filter-paper drip applied to the other side. Is there any uniformity in Vorticella's reactions to the current?[4] Put yeast[5] grains into the reservoir—note behavior toward them—try very fine pulverized chalk, salts of barium, pepsin. Do you find any uniformity in Vorticella's reaction toward these substances. Are the cilia selective in the matter of food getting,[6] or do they admit all sorts of material indifferently at one time and reject all food material whatever, at other times, owing, perhaps, in the latter case to satisfied hunger?

II. Reproductive. Reproduction in *Vorticella* may take place by fission or by gemmation. The former process may frequently be seen, the latter less frequently.

The first signs of multiplication by fission may be seen in the calyx taking on a roundish form, the longitudinal axis shortening. Follow and note all the changes from this stage on till complete division takes place. Note preparations made by the daughter Vorticella previous to its leaving the mother stalk. Do you observe anything that indicates a difference in the sensitivity on different parts of the calyx?

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[1] Kent, Saville: Manual of Infusoria, p. 675.

[2] Nicholson, H. A.: A Manual of Zoölogy. p. 100.

[3] Hodge and Aikens: *Am. Jour. of Psychology*, Vol. VI, No. 4.

[4] Kline, L. W.: *Am. Jour. of Psychology*, 1899, Vol. X, No. 2, p. 260.

[5] Commercial yeast may be used—should be dissolved in sterilized water.

[6] Weir, James: The Dawn of Reason, N. Y., 1899, p. 8.

PARAMECIA.

This hardy, prolific, and swiftly moving infusoria readily responds to a wide range of primitive stimuli, such as gravity, light, contact, temperature and chemical substances. Observations of the responses of such a one celled organism to this varid group of stimuli must be both interesting and instructive to the psychologists.

Paramecia occur in abundance in stagnant water containing decaying vegetable matter.[1] Two or three weeks before they are needed, put hay or grass in a jar of water, and keep in a warm room. In such a jar they may be kept for indefinite periods in immense numbers. To prevent the paramecia on the slide from moving too rapidly, it is advisable to put them in a 2.5% solution of gelatine in water. Study first with the low power, then with the high.

The following structures should be made out: the position and shape of the buccal cavity, nucleus, contracting vacuoles, non-contracting vacuoles, cilia, and trichocysts.

Movements of Cilia.[2] Remove a large number of Paramecia from the culture medium by means of a pipette on to a glass slide. Cover the preparation with a cover glass supported by glass rollers of capillary fineness and of *uniform thickness.* Thrust under the cover slip a couple of pieces of fine capillary glass tubing.[3] After the Paramecia begin to collect along these glass tubes as well as the glass rollers, run carmine water under the cover glass; select a quiet individual and observe how the carmine grains pass by it. Indicate by arrows placed outside the periphery of your drawing the direction of movement of the carmine. What do you infer concerning the movement of the cilia? Do the grains whirl as much about a moving individual as about a quiet one? Can you explain?[4]

Geotaxis. The effect that gravity[5] has in determining the verticality of the body and thereby determining the direction

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[1] Kent, Saville: A Manual of the Infusoria. Vol. II, pp. 483-488. Pl. 26, Figs. 28-30.

[2] Jennings, H. S.: Reactions of Ciliate Infusoria. Jour. Phys., 1897, Vol. XXI, p. 303.

[3] Ludloff in studying the motions of the cilia in electrotaxis confined the animals in a thick gelatine solution. Jennings considered their motion in such a medium as abnormal and recommends water containing carmine grains.

[4] Taken from Davenport's outline of requirements in zoölogy for use in preparing students for Harvard University.

[5] Verworn, Max: Ueber die Fühigkeit der Zelle, activ ihr specifisches Gewicht zu verändern. Pflüger's Archiv, Vol. LIII, 1892, pp. 140-155. See also by the same author: Psycho-Physiologische Protisten-Studien, pp. 121-122.

of locomotion is termed geotaxis.[1] Creatures whose axial orientation and consequent locomotion are perceptibly influenced by this force are geotactic.[2]

(a). Fill half full with the culture medium of Paramecia a glass tube 1½ cm. in diameter and 60 cm. in length. Keep the tube vertical and in uniform temperature and light—not direct sunlight. After a few hours the organisms will be found at and near the surface of the water.

(b). Fill the remaining half of the tube with hydrant water, and, keeping it vertical as before, note the results. Twelve or fifteen hours later they may be found 3 to 6 cm. from the surface of the water (see chemotaxis). Turn the tube bottom side up and observe the time for complete migration to the upper[3] end.[4]

A rough and ready demonstration of this geotactic response may be found by filling a test tube nearly full of the culture medium. To prevent the free end becoming richer in oxygen, seal with an impermeable plug of wax or a rubber stopper. Do not expose the tube to direct sunlight. For the theoretical interpretations of the geotactic responses the student is referred to the works of Verworn, p. 141; Jensen, pp. 462-476; Davenport, pp. 122-124. (See literature given below.)

Chemotaxis. (a). Remove a large number of Paramecia from their culture medium by means of a pipette on to a glass slide. Drop into their midst a small bit of decaying vegetable or animal material. Cover the preparation with a cover glass supported by capillary glass rollers of uniform thickness. Note the behavior of Paramecia toward the decaying material.

(b). Introduce under the cover glass, by means of a pipette drawn to capillary fineness, rancid oils, *e. g.*, olive oil, cod-liver oil. Use also a drop of water from putrefying meat, beef ex-

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[1] Jensen, Paul: Ueber den Geotropismus niederer Organismen. Pflüger's Archiv, 1892, Vol. LIII, pp. 428-480.

[2] Davenport. C. B.: Experimental Morphology Vol. I, pp. 112-125.

[3] Advantage may be taken of the negative geotactic activity of Paramecia for securing large numbers in a small quantity of water. It also serves as a means for washing out the water in which they were bred.

[4] Miss Platt (The Amer. Nat., Vol. XXXIII, No. 385, Jan., 1899,) and Dr. Jennings (Amer. Jour. of Phys., Vol. II, 1899,) report that paramecia in this country are not so markedly geotactic as those used by European investigators. During the fall and early winter of '98 I brought large numbers into small volumes of water by taking advantage of the geotactic responses which they then so readily displayed. In April, '99, I had an occasion to repeat the process. My efforts failed. The paramecia remained scattered throughout the length of the tubes for several days. Both spring and fall cultures were of the same species and reared in similar mediums.

tract, etc. It is best to use a fresh lot of Paramecia for each new substance.

(c). The following salts, acids, and alkalies were used by Dr. Jennings.[1]

Substance.	Wk. Sol.	Stg. Sol.	Substance.	Wk. Sol.	Stg. Sol.
Copper Sulphate	+ ([2])	—	Sodium chloride	—	—
Sulphuric acid	+	—	Sodium carbonate	—	—
Hydrochloric acid	+	—	Sodium bicarbonate	—	—
Acetic acid	+	—	Potassium hydroxide	—	—
Nitric acid	+	—	Sodium hydroxide	—	—
Tannic acid	+	—	Potassium bromate	—	—
Mercuric chloride	+	—			

[2] + = positive and — = negative chemotaxis.

Solutions of H_2SO_4 of the following strengths give positive chemotactic reactions: $\frac{1}{1000}\%$, $\frac{1}{2000}\%$, $\frac{1}{4000}\%$, $\frac{1}{8000}\%$, $\frac{1}{16000}\%$.

(d). Repeat experiment (b) under geotaxis and note that after they have gathered at the surface they recede or fall from 3 to 6 cm. from the surface. Can you explain?

(e). Repeat (a) using a bit of filter paper or a small piece of linen fibre. After they have collected in large numbers about these objects, withdraw by means of a capillary pipette a drop of water from within the area to which the Paramecia are confined. Inject this drop beneath the cover glass of a second preparation in which Paramecia are uniformly distributed. The behavior of Paramecia to this new fluid should be very carefully observed. Their behavior under conditions in experiments (d) and (e) is now believed to be due to the presence of CO_2 excreted in the respiratory process of the organisms. Jennings has shown that they are attracted by weak concentrations of CO_2 and repelled by strong.[2] This fact greatly complicates and oftentimes vitiates experiments in chemotaxis with these animals.

Thigmotaxis. The stimulus offered by mere contact with a solid body is termed thigmotaxis. Animals that have a tendency to cling to, or to move along solid bodies are thigmotactic. Bits of sponge, linen, cotton, or cloth fibre, filter paper or bits of glass may be employed to demonstrate thigmotactic activities of Paramecia. These substances should be sterilized before using. The first gathering of Paramecia about such inert, insoluble bodies is thigmotaxis, but experiments (d) and (e)

[1] Jennings, H. S.: *Loc. cit.*, pp. 258-322.

[2] For a very satisfactory exposition of this subject, together with tests for detecting the presence of CO_2, see the paper by Dr. Jennings already referred to. The same author has given an entirely new and far more satisfactory explanation of positive chemotaxis in a more recent study of Paramecia. See Am. Jour. Phys., Vol. II, May, 1899.

under chemotaxis suggest that a continuation of the gathering in one place is due to the presence of CO_2 excreted. Dr. Jennings[1] concludes that "the reactions which play the chief part in the normal life of Paramecia are *negative geotaxis*, *positive thigmotaxis*, and *positive chemotaxis toward carbon dioxide.*" This is very likely true and at first it might appear superfluous—at least for psychology—to investigate their reactions to any other kind of stimulation. Temperature, however, stands in such vital relations with life in general, necessitating through its frequent and wide variations, ever new adjustments, that it seems advisable to give a method of testing the reaction of Paramecia to temperature.

Thermotaxis. Mendelssohn[2] has demonstrated that Paramecia are negatively thermotactic to temperatures above and below 24°-28° C, and are positively thermotatic to temperatures within and including these limits,[3] *i. e.*, 24°-28° C is their optimum.[4]

An apparatus yielding results quite satisfactory for demonstrational purposes may be constructed on the following plan: (1). A wooden frame—consisting of two uprights 16 inches long and 6 inches apart joined at the top by a cross beam and firmly joined to a wooden foot about 1 foot square; (2) a glass tube 6 inches long and ⅞ inches in diameter with a ⅜ inch hole at its middle point. Close the ends of the tube with cork stoppers containing a ⅜ inch hole bored near the periphery. Insert the stoppers in the tube so that their holes will be as near the bottom of the tube as possible; (3) affix, transversely, on the inside of each upright, ten inches above the foot, a ¼ inch lead pipe one end of which carries a coil of two turns, of diameter barely sufficient to admit the glass tube.

The glass tube may also carry near its middle portion a movable pipe of one coil. Differences of temperature may now

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[1] Jennings, H. S.: *Loc. cit.*, p. 321.

[2] Mendelssohn, M.: Archiv f. d. ges. Physiologie, Vol. LX, pp. 1-27.

[3] His apparatus was simple and excellent. It consisted of a brass plate 20 cm. x 6 cm. and 4 mm. thick, supported in a horizontal plane. To its under surface was attached, transversely, tubes through which hot or cold water was run at pleasure from a reservoir elevated above the plane of the brass plate. In the middle of the plate a space 10 cm. x 2 cm. and 2 mm. was cut out and into which a glass or ebonite trough was fitted. Small thermometers with bulbs at right angles to their stems were placed in the plane of the trough and served to measure the temperature at any point. Desired differences of temperature between any two points along the trough were secured by means of water of different temperatures running through the transverse tubes.

[4] Thermotactic axis-orientation is a reaction to the stimulus created by the difference of temperature between the anterior and posterior ends of an organism. See discussions by Davenport and Mendelssohn.

be secured according to Mendelssohn's method (see note p. 406), or, if connection with hydrant faucets is possible, interpose between the faucets and the lead pipes two metal worms. By applying heat to one, and packing ice around the other, continuous streams of hot and cold water may be secured.

The following rough method readily shows the thermotaxis of Paramecia: Build a trough of wax on a glass slide 6½ x 1¼ inches. Fill the wax trough with "Paramecia water." Place the slide on two flat glass dishes juxtaposed. In one keep hot water, in the other ice. Let the hot water and ice barely touch the under surface of the glass slide. The movements of Paramecia may be followed with a hand lens.

(a). By means of geotaxis secure a large number of Paramecia in a small quantity of water. Pour into the glass tube "Paramecia water" until it barely covers the thermometer bulbs. Too much water will start up currents which impair the results. Find what temperatures attract and what repel Paramecia.

(b). Supposing that Paramecia migrate from a temperature 10° C to a temperature 18° C, and from temperature 32° C to temperature 26° C, make the further experimentation that is necessary to find their optimum.

(c). *Acclimatization.* Mendelssohn[1] found that, if Paramecia be kept in a temperature from 36°-38° C from 4-6 hours, and then placed in a rectangular vessel whose end temperatures are 24°-36° C respectively, they will occupy a position corresponding to 30°-32° C. If, however, they are kept in a temperature 18° C and then placed in the vessel whose end temperatures are suddenly raised, they reach their optimum at 24° C.[2] Repeat this experiment. What inferences may be drawn from the facts of acclimatization?

HYDRA. (*Hydroidae.*)

These fresh water polypys belong to the primitive forms of double walled animals (coelenterata.) They (coelenterata) present to us for the first time organs and tissues composed of cells, and the *co-ordination* of different parts in the performance of certain activities, *e. g.*, simultaneous closing in of tentacles on some object of prey.

Fresh water hydra may be obtained by gathering from fresh pools Lemna, sticks, and grass and putting them into an aquarium. Hydras, which are attached to these objects, will then

[1] Mendelssohn, M.: *Loc. cit.*, pp. 19-20.

[2] Davenport, C. B.: *Loc. cit.*, 1899, pp. 27-32. See also Loew, O.: Ueber den verschiedenen Resistenz grad im Protoplasma. Archiv f. d. ges. Physiologie, 1885, Vol. XXXV, pp. 509-516.

usually migrate within a few days to the light side of the vessel. Hydras can be kept readily throughout the winter in a large glass jar containing Lemna, chara, water cress, and Entomostraca for food.[1]

Touch. Place a Hydra in a watch-glass full of water. Touch the tentacle with a needle. What movements?

Selecting Food (*Taste*). (a). Drop cautiously and at intervals of a few minutes upon the surface of the water over the tentacles of the Hydra a drop of water, of sugar solution, of acid. What differences in the movements?

(b). Bring a Daphnia (previously stranded) on the end of a needle to the tentacles of the Hydra. Note the result. With another Hydra, use a bit of plant tissue.

Reaction to Light (*Photopathy*).[2] Place in a small glass jar full of water containing Lemna and Entomostraca two or three large, budding Hydras. Cover the jar with a box, placing the slit next to the window. Means of aeration should be supplied the glass jar. Note at short intervals for two weeks the position and number of Hydras in the jar.[3]

"Place a Hydra in a watch-glass with a little water, and by means of a needle and a penknife cut it into two or three pieces. Let the pieces expand and draw them. By means of a clean pipette place the pieces in a small Stender dish, in clean water. Draw the pieces again after 24 hours, and after a longer period if necessary."

EARTH WORMS. (*Lumbricus Agricola.*)

Worms changed the course of animal evolution from a radial to a bilateral form and established permanently the very fundamental principle of metamerism. Those that have migrated from water to land have, by reason of their crawling habits, greatly accentuated all those differences, begun in the sea, between ventral and dorsal parts, between anterior and posterior ends. These structural and physiological differentiations have an interest for the psychologist in that they express a correlation between the degree of sensitiveness and the relative use of the parts of an organism.

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[1] For anatomical descriptions of Hydra see Manuals of Zoölogy.

[2] "The wandering of organisms into a more or less intensely illuminated region, the direction of locomotion being determined by a difference in intensity of illumination of the two poles of the organism, is photopathy." Davenport: Experimental Morphology. Part 1, p. 180. See also Vitus Graber: Grundlinien zur Erforschung des Helligkeits und Farbensinnes der Thiere. pp. 318, Leipzig, 1884.

[3] Wilson, Edmund B.: The American Naturalist, Vol. XXV, pp. 413-425, 1891. This paper of Prof. Wilson's contains also an account of Hydras reactions to colored light.

The nature[1] of the soil, as to its compactness, moisture, fertility, that is most favorable to the presence of earth worms; the shape and contents of their burrows; the relation of the amount of their castings to the changes of the weather—all must be studied out of doors in their natural habitat.

Sense Organs. Miss Langdon's[2] anatomical studies have demonstrated very thoroughly, "that the sense organs are distributed over the entire surface of the body, but are most numerous and largest at each end." [3] It has also been found that the anterior and posterior portions of the body react to weaker solutions of strychnine and saccharine than do the middle portions.

Reactions to Chemicals. Apply very gently to different portions of the surface a few drops of strychnine varying in strength from 1: 10000 to 1: 100000; also solutions of different strengths, of saccharine and creosote.

Touch. Their sensitiveness to touch or a jar may be seen by tapping gently a vessel containing them. Blow the breath gently against the head end,—what effect?

Sight. Earth worms may be kept for an indefinite time in earthen jars containing rich soil. (a). Keep the entrance of their burrows illuminated all night, compare in the morning by weight the amount of castings with those of the previous morning. (b). Compare also the amount of food eaten with that of the previous night. (c). During the day expose (taking care to avoid jarring the vessel) the top of the vessel suddenly to the light—note how quickly the worms disappear beneath the surface when the light flashes on them. (d). Cover a pane of glass with moist filter paper, place a worm upon it and set the glass near a window—record the reactions of the worm. (e). Allow direct sunlight to fall upon the head end of the worm, the tail end, the middle. Make note of the reactions.

Food. Give at night three pieces each of the following vegetables—celery, potato, cabbage, apple and onion—all cut wedge shaped. Arrange the pieces of each vegetable, thus cut, in the form of a star, with their bases toward a common center. Note in the morning what pieces have been most eaten and the relative position of the pieces that have been

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[1] Darwin, Charles: The Formation of Vegetable Mould through the Action of worms, with observations on their habits. D. Appleton & Co., New York, 1885, pp. 326. This book should be read by every student of nature, not merely for the subject matter *per se*, but more particularly for the method and spirit that is so admirably brought to bear on a group of commonplace facts.

[2] Langdon, Fanny E.: Am. Jour. of Morphology, 1895, Vol. VI, p. 218.

[3] Lenhossek, Michael V.: Ursprung, Verlauf und Endigung der sensibeln Nervenfasern bei Lumbricus. Arch. f. Micros. Anat., 1892, XXXIX, pp. 106-136.

disturbed. This should be repeated often enough to establish with certainty the presence or absence of a preference for certain foods.

Taste. Dip a piece of cabbage or celery into a strong solution of quinine and place it near a fresh piece of the same food, of same size and shape—notice whether the piece dipped in quinine is disturbed during the night.[1]

Smell.[2] (a). Bring near to the head end of the worm in succession bits of sponges or filter paper saturated with water, with sugar solution, with onion juice, with acetic acid, and with beef extract. Does the worm react? (b). Bury in a hole about the size of a hen's egg a piece of onion. Pack the earth firmly, bury a second piece near by in a similar way, but do not pack the earth.[3] Notice which is first disturbed.

Boring (a). Place three or four worms in a pot of loose earth and note the time in which they disappear. (b). Press and pack the earth and repeat the experiment. (c). Try different kinds of soils—note where the worms go down. Do they swallow the earth while boring? Methods and rate of boring may be conveniently observed in tall narrow glass jars.[4]

Methods of Burying. (a). Place without order in a jar over night fifty dead pine needles. In another jar the same number of green pine needles. Note the next morning the arrangement of dead and green needles. (b). Make the same experiment during the day time—after covering the top of the jar with a black cloth. (c). Put dead pine needles in both jars; keep one jar in a temperature of about 22°C over night, and the other out doors uncovered. Compare the number of needles drawn in.

SLUGS. (*Limax Maximus.*)

This species of *gastropoda* may be found[5] during the warmer seasons in gardens, orchards, dairy houses and the like, and during the winter seasons in greenhouses. They seek dark, shady, damp places.

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[1] Graber, Vitus: *Loc. cit.*, pp. 290-295.

[2] After Darwin's, probably no other work on the senses of earth worms is more helpful and suggestive than that of Nagel's. Bibliotheca Zoölogica, Sept. 18, 1894, pp. 146-150.

[3] This experiment was used by Darwin to test the worms sense of smell. The food placed in the loose earth was usually found first. Might not this be partly due to the fact that the loose earth offered easier penetration to the worm?

[4] For the power of worms to regenerate lost parts see T. H. Morgan's paper in Anat. Anz. Bd. 25. No. 21, s. 407, 1899.

[5] I keep them alive all winter in a wooden box partly filled with rotten wood and rich soil taken from their natural habitat. They eat vegetables, fruits and meat.

Sense Organs:[1] Eyes, auditory vesicles (otocysts), tactile and olfactory organs are present.

Senses. They react to odors,[2] sound, touch, light, heat and gravity.

Sense of Smell.[3] (a). Reactions to odors in the form of liquids may be secured by putting a band or stream of the solution on a pane of glass at right angles to the snail's line of motion. Do you find characteristic reactions toward different odors. Look for objectionable and unobjectionable odors; (b) note in seconds, in each case, the interval elapsing before the first responses.

Sight. (a). Do they discern objects?[4] Weir[5] is inclined to think that they do. "The snail carries its eyes in telescopic watch-towers . . . and, as semi-prominent and commanding view points are assigned to its organs of sight, one would naturally expect to find a comparatively high degree of development in them." His experimental test runs thus: At the end of a ten foot pole suspend, by means of a string, a white or black ball. The ball is made to describe a pendulum-like movement to and fro in front of the snail on a level with the tips of its horns. I suggest that a pane of glass be interposed between the snail and the swinging ball, thus preventing the possibility of creating disturbing air currents. (b). Put a specimen on a pane of glass 8 x 10, and place the glass horizontally near a window and let the slug be parallel to the window. Do not let direct sunlight fall upon it.[6] Plot the position of the slug at intervals of ten seconds.[7]

Taste.[8] Nagel[9] believes that the lips and mouth parts of the slug are moderately susceptible to taste stimulus. By means of a pipette, place one at a time, and at right angles to the snail's line of motion, a band of distilled water, of a weak solution of sugar, of acetic acid, of quinine, of alcohol, of cheese-water, of meat juice, etc.,—make a record of its behavior on reaching the different bands of solution.

Locomotion. Place the slug on the glass and study its locomotion from the under side of the plate.

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[1] Claus and Sedgwick: Text-book of Zoölogy. 1884, Vol. II, p. 34.

[2] Spengel, J. W.: Die Geruchsorgane und das Nervensystem der Molluskin. Zeit. f. wiss. Zoöl., Vol. XXXIV.

[3] Nagel, Wilibald A.: Bibliotheca Zoölogica, heft, 18, pp. 163–168, 1894.

[4] Lubbock, Sir John: Senses, Instincts, and Intelligence of Animals. p. 140.

[5] Weir, James: *Loc. cit.*, pp. 18-20.

[6] Hot water or a solution of ether and alcohol will cleanse the glass of the slime which should frequently be removed.

[7] Loeb, J.: Der Heliotropismus der Thiere. Würzburg, 1890, pp. 93-100.

[8] Lubbock, Sir John: *Loc. cit.*, p. 22.

[9] Nagel, W. A.: *Loc. cit.*, p. 164.

Geotactic Sense. A rough and ready demonstrational method is to place the slug on a pane of glass, parallel to one edge of the pane, hold the pane vertical and shield from lateral lights. Represent graphically the position of the slug at the beginning of the experiment, and at intervals of ten seconds, for about a minute.

The geotactic sense of the slug has been so well demonstrated by Davenport[1] that I can do no better than give his methods. A dark, wooden box of cubical form about 35 cm. in diameter, a dense, opaque, black cloth to cover the open side of the box which must be directed upwards, are required; a glass plate about 30 cm.[2] square carries the slug and is so placed in the dark box that one edge fits into one of the lower angles of the box while the opposite edge may be elevated to any degree ranging from 0° to 90°. Measure the angles off, upon one side of the box, and bore a hole at every fifth degree, so that the glass plate may rest on plugs inserted into the holes. The angular deviation of the axis of the body during a given time from the position in which it was first placed may be measured off by means of a protractor.

If the student desire to pursue the question of geotaxis further, he may investigate to answer the following questions, which may readily be determined by experimentation. (a). "What relation exists between a variation in the pressure of gravity and the precision of orientation?" (b). "What is the limiting pressure which will call forth the geotactic response?"[3]

The former is demonstrated by ascertaining the angular deviation of the slug from a vertical position upon the plate at various inclinations from 0° to 90°, and after the lapse of a constant time (45 seconds). The data gained in answer to the first problem furnishes an answer to the second.

Preliminary to (a): Ascertain whether the *quickness* of the response of the slug is modified by the strength of the action of gravity, *i. e.*, does the slug respond as quickly and effect as complete an orientation at say 15° as at 75°? For this purpose, place the slug on the glass so that its long axis is parallel to the lower edge of the plate. Set the glass successively at 60°, 45°, 30°, 20° and 15°, and make five tests at each angle upon one and the same slug. Two time intervals should be taken: (1) the time elapsing before the first response to gravity occurs, and (2) the interval required for

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[1] Davenport, C. B.: Jour. Phys., Vol. XXII, pp. 99-110, 1897-98.

[2] I receive satisfactory results from a box 10 x 8 x 7 inches deep.

[3] In addition to these questions, Dr. Davenport asks a third: What determines the position of the head end? A solution of this question involves experimentation beyond what is contemplated in this course.

the organism to place its entire axis in a vertical position. To avoid exposing the slug to the action of light during the preliminary experiment, the completeness of orientation should be observed after different periods of time, *e. g.*, at the end of 30, 40, and 50 seconds. That period in which orientation is just effected should be the time selected for future experiments.

(a). Set the plate at the following angles: 90°, 60°, 45°, 30°, 20°, 10° and 0°. At each angle make six determinations on each one of five slugs. For each angle find the mean of the thirty determinations of the angular deviation of the slug from the vertical position, (b) note the extreme deviations from the vertical in the case of each slug.[1]

Fish.

A study of fishes in the interests of comparative psychology is exceedingly desirable, for the reason that they stand at the bottom of the great back-boned series of animal life presenting in a simple and fundamental form all the essential structures characteristic of that group. To the fish we owe a debt for having encased the nervous system in a bony vertebral column, for developing an efficient neuro-motor mechanism operating about a stiff longitudinal axis, and for having "staked out" or laid down the ground plan of the nervous system on which the forces of evolution have erected the complex structures of higher forms.

The following are some of the fish suitable for such a study; pickerel[2] (*Esox Americana*), perch (*Perca Americana*), goldfish (*Cyprinus Auratus*), horned pout, common bull head (*Ameiurus nebulosus*) and shiners and spotted tail minnows (*Notropus hudsonius*) and stickle-back (*Eucalia inconstans*). Both pickerel and perch should be kept in large aquaria supplied with a continuous flow of water—a forced stream is preferable. Chara, water cress, or other water grasses should be supplied and, of course, permitted to *grow*. Shiners, earth worms, newts, young frogs serve as food. Gold fish do not require constant running water. It should be changed, however, every week or two. Supply the aquaria with sand and pebbles, and grasses —like water cress, cabomba, chara.

Food for gold fish may be had of the dealers.

Food. (a) Feed regularly—daily or every other day depend-

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[1] See also Geotaxis by Davenport, Experimental Morphology, Part I, p. 119.

[2] The scientific names of North American fishes can be found in U. S. Com. of Fish and Fisheries, report of 1895, pp. 209–590. This work was prepared by President David Starr Jordan and Dr. B. W. Evermann.

ing on the species and somewhat on the season. Note the time required for the different species to recognize your approach and presence.[1] Do some never learn to recognize you? (b). Compare the manner in which, *e. g.*, perch[2] and pickerel seize their food (live minnows). Can you account for the difference? (c). See if you can detect a carnivorous fish stalking its prey. (d). Cut the rice wafer preparation for gold fish into pieces about 1 cm. square. Give the fish, along with the two or three pieces of wafer, a piece of decided yellow paper cut like the wafer in size and shape. Note carefully the results. Repeat the experiment often enough to justify a conclusion. Next give them paper of a much lighter yellow and observe their behavior toward it. Is it touch or taste or both that acquaints them with the paper? Finally, give them cut pieces of white filter paper, which very closely resembles the rice wafer. At each experiment do not give more than two or three bits of rice wafer with the one piece of paper. It would be of great interest to find out if the gold fish would ever learn not to strike at the white filter paper. (e). Feed[3] perch on shiners for three months, then partition off a portion of their aquarium with a pane of glass. Every other day, at the feeding hour, put shiners in the new division. Note on each occasion the number of attempts made by the perch to catch the minnows. Remove the minnows from the tank at the end of each observation. Feed the perch earth worms on days not experimenting. Should the perch finally become indifferent toward the minnows, remove the glass partition. Note the effect. (f). Some fish, like pickerel, appear to have "table manners," others, like sticklebacks, snatch at times the food from each other's mouths as do the hens.

Temperature.[4] The sensitiveness[5] of fish to temperature varies greatly among different species. (a). If a minnow be transferred from a temperature of about 20°C to 2°–4°C, and allowed to remain ½ minute, it will soon appear as dead. If,

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[1] McIntosh, W. C.: Note on the Memory of Fishes. Journal of Mental Science, Vol. XLIV, pp. 231–235, 1898.

[2] Neither pickerel nor perch eat dead fish.

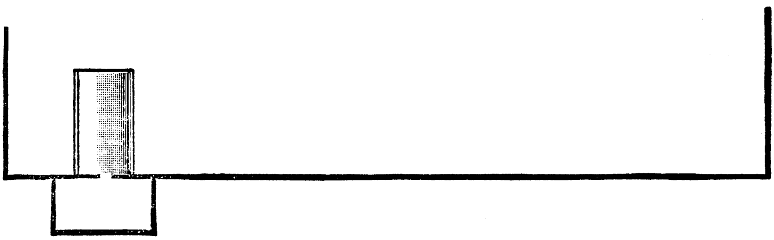
[3] This experiment was suggested by the famous experiment of Möbius on pike. The story runs that pike, having lived for some time in a tank separated by a glass plate from another in which small fish were living finally desisted from trying to catch them, and on the glass plate being removed made no attempt to molest the small fish. See interpretation by Prof. Bateson. Journal of Marine Biological Association, pp. 243, 1890.

[4] For an account of some experimentation and observation on the Sense-Organs and Perceptions of Fishes, see W. Bateson in Journal of Marine Biological Association, Vol. I, pp. 239–248.

[5] Goode, G. Brown: U. S. Fish Com. Report, 1877, pp. 51–72.

after a minute, it be transferred successively through 10°C, 15° C, and back to 20°C, life returns;—transferring directly from 2° to 20°C often kills the fish.

(b)[1] The following apparatus may be used not only for testing their sensitiveness to temperature, but also for finding their optimum. (I suggest that the test be made with shiners, using



20 or 30 at a time). A zinc trough about 20 cm. deep, 16 cm. wide and 2.4 meters long supported by a wooden frame. [See cut.] Solder to the bottom of the trough 16 cm. from one end a tin box 12 cm. wide, 15 cm. long and 6 cm. deep. The box receives water through a hole cut in the zinc trough. Solder a stand-pipe to the zinc trough about the hole leading to the tin box. Apply heat to the tin box. The water in the trough should not exceed 2½ inches in depth. The end opposite the tin box should rest on iced sawdust. Ice may be applied to the sides of the trough, and also put in the water to secure desired differences of temperature. Lay lengthwise of the trough a strip of board containing ¼ inch holes about six inches apart. Thrust thermometers through the holes and into the water two inches below its surface.

Sight.[2] Observations[3] made on different species readily show that there are wide differences in their range of vision, *e. g.*, perch appear to recognize the human figure about 30 feet away, minnows 20 to 25 feet away and pickerel 10 to 15 feet.

With the room darkened and with a magic lantern mounted

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[1] An apparatus of this sort gave satisfactory results in searching for the optimum temperature of tadpoles. See *Am. Jour. of Psychology*, 1898, Vol X, No. 1, pp. 8–10.

[2] Bateson, W.: *Loc. cit.*, pp. 242-248.

[3] One may connect with observations on the sight of fishes experiments and observations on their color changes. The horned pout is said to alter its color when transferred from a white to a dark dish. Abbott and others cite cases of color changes during emotional excitement. The different hues on my perch are more pronounced after an exciting chase for a minnow. It appears that changes in the intensity of light causes apparent changes in color.

on a rotating table placed about three feet from the aquarium, throw a bright light on the aquarium in the region of the fish. Should the fish finally move away or just out of the zone of light, rotate the table until the light covers his entire body. See if, by repeating this process, you can drive them back and forth between the ends of the aquarium. It would be interesting to see if they react toward colored light as toward white. Bateson found no appreciable difference in the reaction toward white and colored light among the species tested by him.[1] Give to a species of day feeders food at night,—note their behavior by means of a dark lantern.

Hearing. Ichthyologists[2] are generally agreed that fish do not hear sounds transmitted by air waves.[3] The ear apparatus is usually interpreted as an organ for equilibration. They do respond to vibratile motions imparted to the water by solid bodies. Some fish are known to make noises, and even musical sounds which are heard by other fishes of their kind. Would acuteness of hearing be of any advantage to the fish?

Emotions. The works of Romanes, Brehm, Günther, Darwin, Abbott and others cite instances of the activities of fish that are expressive of fear, pugnacity, social, sexual and parental feelings, anger, jealousy, play and curiosity. How many of these emotions do you notice?[4]

Chicks.

"I have now described, perhaps in undue detail, a few of my observations as noted down at the time. To some they may seem trivial, and scarcely worth the making and the noting. To us, as students of comparative psychology, their interest lies in the light they throw on the beginnings of psychical life and activity in the chick or duck."—*Morgan*.

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[1] Bateson, W.: *Loc. cit.*, pp. 251-252.

[2] Lee, F. S.: A Study of the Sense of Equilibrium in Fishes. Jour. of Physiology, Vol. XV, pp. 311-348.

[3] Kreidl, Alois: Ueber die Schallperception der Fische. Archiv f. d. ges. Physiology, 1895, Vol. LXI, pp. 450-464; also Ein weiterer Versuch über das angebliche Hören eines Glockenzeichens durch die Fische. Archiv f. d. ges. Physiologie, 1896, Vol. LXIII, pp. 581-586.

[4] From my observations on shiners, I am persuaded that they, at least, possess the capacity for feigning death. Pickerel will not eat dead fish—at any rate mine do not. Sometimes they are not successful at the first two or three attempts in seizing a shiner. These unsuccessful attempts greatly excite the small fish, which dart hither and thither pursued by the pickerel. The chase may finally be given up or the pickerel may seize one, after which all becomes quiet. It is at this period that the lucky shiner seeks a dark place and lies flat on one side as when dead. I have been deceived several times myself when, on going to remove them from the tank, thinking they were dead, they would dart with lightning speed to some new quarter.

The fact that chicks can be reared under test conditions and by the care of foster-parents, makes it possible to see more clearly just what responses are due to inheritance, *e. g.*, pecking, cuddling, making their toilet; and what are due to sense-experience, operating under the principles of association, *e. g.*, responses to agreeable and disagreeable foods.

First Day. Senses[1]. (a). While peeping in the shell,[2] whistle,[3] clap the hands near the egg, hold a tuning-fork near—is there a response to these sounds?

(b). After they have recovered from the "catastrophe of birth," repeat the sounds made in (a) and others that suggest themselves. Repeat this at ages 12, 24, 36, and 48[4] hours, respectively, and note the differences in responses both as to the increasing perfection of the sense of hearing and in the expression of the emotions.

(c). Has tapping on the floor near the food with a pencil any suggestive[5] value—through the auditory sense—to the chicks pecking?

2. Note behavior toward different odors, *e. g.*, spearmint, iodoform, cologne, cheese, asafœtida, etc. Odors may conveniently be presented on bits of cotton batting held by forceps.

3. At about the age of 12 hours test the field of vision by dropping bright bits of shell or meal before them. Move the food back and forth, up and down, before them. Do they peck at food beyond their reach?[6] Is it necessary to touch the eye to get a winking reflex?

4. Touch their feet with cold, medium, and quite warm wire—note the response in each case. Note fondness for sunshine.

Instinctive Movements.[7] (a). Note efforts to stand,[8] to walk[9] follow moving objects[10]—do they show preferences here? Note position of head and neck when sitting. Whenever possible early movements of other birds should be noted and

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[1] Suggestions and directions for hatching chicks by means of an incubator may be had by writing to any reputable manufacturer of incubators.

[2] Morgan, C. Lloyd: Habit and Instinct, 1896, pp. 31-32.

[3] Hudson, W. H.: Naturalist in La Plata, 1892, pp. 99.

[4] Spalding, D. A.: Instinct. Macmillan's Magazine, Feb., 1873, Vol. XXVII.

[5] Darwin, Charles: Expression of the Emotions, 1872, p. 47.

[6] Preyer, W.: The Mind of the Child, p. 239. Translated by H. W. Brown, 1888.

[7] Preyer, W.: *Loc. cit.*

[8] Morgan, C. Lloyd: Habit and Instinct. Chapter 3.

[9] Mills, Wesley: The Nature and Development of Animal Intelligence.

[10] Groos, Karl: The Play of Animals. Chapter 3.

compared with those of chicks, *e. g.*, standing, walking, and swimming of the duck. (b). Make a list of all those activities that may be regarded as instinctive, *i. e.*, "congenitally perfect," as pecking, cuddling (do they show a preference here or do they cuddle indifferently under any object)? Do loud, sharp sounds shock or frighten them?

Voice. How many distinct sounds can be distinguished at this age?

Second Day. 1. Repeat experiments on the senses, adding to the list experiments on taste by giving them bits of lemon and orange[1] peelings, or a bit of blotting paper of pronounced color saturated with quinine. Note with special care the increased perfection of sight and hearing.

2. Note all activities of food getting, such as pecking, seizing, bill-movements, swallowing, etc. Offer them water (water should not be offered earlier than the second day), and observe just how they come to drink. Offer them an earth worm, beetle, or the like, and note the effects of competition. Imitative[2] acts are liable to occur at the end of the second and the beginning of the third day. For discovery[3] and accurate description they require careful observation.[4] What is the nature of the activities imitated, racial or acquired?

3. Observe the following: (a) certain activities fading out, (b) new ones appearing,[5] *e. g.*, preening feathers, flapping wings, wallowing, scratching—will they scratch on a bare surface, or do they require a bit of sand or grain to touch off the scratching apparatus? these may not occur until third and fourth days. (c) Are there any which they do from individual experience?

Memory and Associations.[6] To study the formation of associations in the chick the sense of taste may easily be employed. Offer them some bitter or disagreeable substance of a pronounced color as food. The number of experiences which the chick has with the disagreeable substance before it avoids or neglects it altogether is a rough measure of the time required for a permanent association to be formed between the color of the food and its disagreeable effects when taken into the mouth[7]

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[1] Hunt, H. E.: *Am. Jour. of Psychology*, 1897, Vol. IX, pp. 125-127.

[2] Morgan, C. Lloyd: *Loc. cit.*, pp. 166-185.

[3] Romanes: Mental Evolution in Animals, pp. 222-223.

[4] For imitative movements in the child, see Preyer: The Senses and the Will. Tr. by H. W. Brown. pp. 282-292.

[5] James, W.: Psychology, Vol. II, pp. 394-402. See Transitoriness of Instincts.

[6] Thorndike, E. L.: Animal Intelligence. Supp. Psy. Rev., 1898, pp. 65-78.

[7] Morgan, C. Lloyd: Introduction to Comparative Psychology, 1894. Chapter 5, Association of Ideas in Animals.

An experiment of this sort may require several successive days of observation. The permanency of the association should be tested by offering the objectionable substance several days apart.[1]

Third Day. Instinctive Activities. Note the first appearance of attempts to scratch the head, to wallow, to play, and under what conditions these things occur.

Emotions. Joy, fear, anger may be expressed at this age.

Solitude and Society. The effect of solitude may be observed by isolating one chick completely from his kind—not even letting it hear the voices of other chicks. Feed it on a limited variety of diet. At the end of four or five[2] days, introduce it to a flock that have enjoyed society and a larger variety of experience. Observe its initiation into this larger world.

The above outline, covering the first three days of chick life, and indicating the kind of observations to be made for the advantage of psychology may be continued with profit twelve to fourteen days, the duration depending largely upon the problems set for the chicks to do.

THE WHITE RAT.

"No ghost story or tale of horrid murder has been considered quite complete without its rat peering from some dark corner."—*Cram.*

To Mr. Willard S. Small I am greatly indebted for both the form and matter of this section. The outline here presented by Mr. Small for studying this rodent is based on his own very painstaking investigations, which have extended over nearly two years. With appropriate variations—dictated of course by the instincts, dominant traits, etc., of the rodent to be studied, the outline may serve for further investigations on other members of that family.

The white rat presents some modifications of the psychical character of his wild congeners,[3] but these are comparatively slight. The description given by Brehm[4] of the character of *mus decumanus* applies to the domesticated white rat with almost equal accuracy. The principal difference in psychic outfit is the inferiority of vision in the white rat. The eye is unpigmented and seems to be a much less important instrument than with the wild varieties.[5]

On account of their early maturity, healthiness (under nor-

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[1] Kline, L. W.: *Am. Jour. of Psychology*, Vol. X, p. 273.

[2] *Ibid.*, pp. 271-272.

[3] Brehm: Thierleben (Saügethiere, Vol. II, p. 342 ff.). A characterization of the species *Muridae*.

[4] Brehm: *Loc. cit.*, p. 349.

[5] Rodwell, James: The Rat (London: Routledge and Sons) is a mine of anecdotal literature upon the rat,

mal conditions[1]), gentleness and cleanliness white rats are well adapted for experimental studies.

1. The Psychic Development of the Young Rat. The white rat, born blind and deaf, passes through two distinct phases of psychic development:[2] the period before, and the period after, sight and hearing begin to function. The method in this section is to follow the development of the animal's psychical activities from birth until the age of five or six weeks. The only factor appearing after this age is the sex instinct. This appears about the ninth or tenth week.

SENSATION.[3] *First day.* 1. *Smell.* Test[4] with several substances, *e. g.*, fresh milk, cologne water, hydrochloric acid. Observe: (a) the character of the reactions—how many kinds? (b) whether the reactions seem to indicate pleasure or displeasure in each case; (c) can you distinguish between the act of sensing and the motor reaction? (d) do you distinguish the vibratory movements of the nostrils so characteristic of the rodents?

2. *Taste.* Open the mouth and place upon the tongue: fresh milk, honey or sugar solution, aloes or quinine solution, or other substances. Observe: (a) the reactions; (b) whether they seem to indicate discrimination of tastes.[5]

3. *Tactile Sensibility.* (a) Touch the skin lightly on various parts of the body; (b) draw a bristle across the back, flank or side, and over the nose; (c) pinch very lightly the tail, foot, and sides or flank; (d) touch any part with a cold wire (32°), and then with a hot wire (not hot enough to burn); (e) notice also the rats' extreme sensitiveness to changes of atmospheric

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[1] The following conditions should be observed: (1) the rats must be kept in a warm room—temperature not lower than 50° F.; (2) the floors of the cages should be covered one inch deep with clean sawdust; this should be changed at least once a week; (3) the cages should be so arranged as to protect the rats from strong light; (4) a simple diet of dog biscuit and milk and occasional green stuff, *e. g.*, apples or lettuce, gives good results. Fresh water each day. Offensive odors are minimized by carefully observing (2) and (4).

An excellent observation cage may be made as follows: dimensions, length, 20 inches; height, 16 inches; width, 16 inches; floor, back, and top of wood; one end of wire mesh (¼ inch) for ventilation; front and other end of glass. This insures observation of all activities, and is large enough for the introduction of necessary apparatus.

[2] Mills, Wesley: Animal Intelligence, p. 167.

[3] In connection with the observations upon sensation, it will prove interesting and suggestive to note the conditions of the sense organs.

[4] Bits of paper held by forceps are convenient for this purpose. The odorous substance should be held from 2 to 5 mm. from the nostrils. Other odors and irritating fluids should be used. For similar tests upon other rodents, cf. Mills, W.: *Loc. cit.*, p. 234, 241. Distinguish carefully between the effects of odors and irritating fluids.

[5] Mills, Wesley: *Loc. cit.*

temperature as indicated by rapid lowering of bodily temperature and retardation of heart-beat when brought from the nest into a cooler atmosphere; (f) observe also their apparent satisfaction when covered with the hand.

4. "*Sense of Support.*"[1] Place the young rat near the edge of the table, and note whether it crawls off or hesitates at the edge and shows uneasiness.[2]

5. *Sense of Position.*[3] Place the rat upon a pane of glass in horizontal position, with the sagittal axis of body parallel with two sides of the pane; then tip the pane—each end and side in turn—and note the angle required to elicit a response, *i. e.*, an effort to compensate the inclination of the pane.

Second to fifteenth day.[4] Follow the same line of observation, noting these more general points.[5]

1. *Smell.* (a). The tests may be made with the same substances, or variations may be introduced. In the former case, note the effect of growing familiarity upon the reactions; (b) note whether there is any diminution in the time required for sensing the stimulus; and (c) distinguish between sensing of stimulus and motor response.

2. *Taste.*[6] The experiments need not be repeated more than twice during the first week; after that, every second day.

3. *Instinctive Activities.*[7] *First day.* 1. When the young rats are held in the hand, observe their tendency to roll up into a ball. 2. Place them upon a smooth table and observe their efforts;[8] (a) to stand, (b) to crawl, (c) to hold up and move the head from side to side; (d) observe further whether they seek to get together; explain the reason of this movement and consider whether it has any significance for

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[1] Mills, Wesley: Animal Intelligence, pp. 118, 150, 176, 225. Morgan, C. Lloyd: Habit and Instinct, p. 107.

[2] This experiment *may* be impracticable the first day on account of the limited locomotion of the rats.

[3] Sanford, E. C.: Experimental Psychology, p. 36. Lee, F. S.: Jour. of Physiology, Vols. XV and XVII.

[4] Weigh the rat and measure length of body and head from time to time.

[5] Mills, W.: *Loc. cit.* Prof. Mills's work should be familiar. The differences brought out in his studies, between young animals of different species, are most instructive. Preyer, W.: The Mind of the Child—the Senses and Will. (Tr. by H. W. Brown.) p. 257 ff.

[6] The experiments on taste and smell may be varied profitably by introducing the factors of hunger and satiety. Compare rats taken at random from the nest with some that have been segregated for two to four hours, according to age. (N. B. Keep them warm.)

[7] Morgan, C. Lloyd: Habit and Instincts. Ch. 5. For a discussion of "Instinct," cf. Ch. 1. Also Groos, Karl: The Play of Animals. Marshall, H. R.: Instinct and Reason (MacMillan, 1898). James, W.: Psychology, Vol. II, Ch. 24.

[8] For comparison with other rodents, cf. Mills, W.: *Loc. cit.*

the origin of the "social instinct." 3. Turn them over upon their backs; note their efforts to turn over upon their bellies; note also the variety of movements in these efforts and the lack of muscular co-ordination.

4. Try to observe the sucking activity from the first.[1] (a) Do the new-born rats find the mother's teats immediately by a "congenitally perfect instinct," or is there accident in the process? (b). Do they suck any other part of the mother than the teats? (c). Does the mother render assistance?

5. Test their clinging power—letting them cling, unsupported, to your finger.[2] The attempt should be made constantly to infer the sensational and affective states correlative with the instinctive activities.

6. *Vocal Expressions*. Note carefully the number of sounds you can distinguish clearly, and what affective states they severally indicate.[3]

The eyes and ears begin to function about the fifteenth day. Between the second and the fifteenth days, two facts of a general nature relating to motor activities should be noted: (a) the increasing vigor of movements, and (b) definiteness of muscular co-ordination. Note especially, the progressively effective use of the paws in sucking.

In respect to vocal activities, it should be noted whether they increase in variety, and whether they are indulged in more or less frequently.

New features in development may be looked for as follows:

About the seventh day, note that they begin to move about more freely, selecting their paths to some extent and avoiding obstacles.

Tenth to thirteenth day. 1. Look for the appearance of some very characteristic "rat" activities: (a) orientation, by rising slightly upon the hind legs and sniffing about, when they are moved into a new place; (b) climbing up on the mother's back and up the side of the cage; (c) scratching the body with the hind foot;[4] (d) washing the face with the fore paws. 2. Observe about this time also that they may leave the nest and follow the mother in order to suck.[5]

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[1] Mills, W.: *Loc. cit.*, p. 118 ff. Morgan, C. L.: *Loc. cit.*, p. 113. Hudson, W. H.: The Naturalist in La Plata, p. 106. Wallace, A. R.: Contributions to the Theory of Natural Selection, p. 206. Preyer, W.: The Senses and Will, p. 257.

[2] Robinson, Dr. Louis: Nineteenth Century, Nov., 1891. (This instinct in the human child.)

[3] Contrast with rabbit, Mills, W.: Animal Intelligence, p. 134.

[4] This is called by Romanes a pure reflex. Cf. Romanes, G. J., Darwin and after Darwin, part 2, p. 80.

[5] I have seen one leave the nest and go directly to the mother, a foot away, eating her supper. Whether this was by chance or by smell is an interesting question.

A test for instinctive fear may be made by rubbing a cat and then presenting the hand to the nostril of the rats.[1]

At the end of the first period, it will be well to "take account of stock," summarizing the psychical elements that have now appeared, noting their time of appearance—congenital or later—and their order of development.

SECOND PERIOD.

The following suggestions for this period may serve for a general outline, to be varied or discontinued at discretion.

SENSATION. 1. *Smell.* Tests should be made now especially with food substances, *e. g.*, milk, cheese, honey, meat, etc. Tests may be made also with essential oils.[2]

2. *Test.* Discrimination of taste, by putting edible and non-edible substances into the mouths of the rats, *e. g.*, dog biscuit and sealing wag.

3. *Hearing.*[3] (a). Tests should be made for hearing just before the external meatus is completely open, by clapping the hands, clucking, hissing, whistling, etc. Be careful that a current of air is not thrown upon the rats with explosive noises. (b). Generally the sense of hearing becomes acute about the fifteenth day. (c). Try a number and variety of sounds, especially musical tones (a gamut of tuning forks is desirable). Also introduce variations in loudness.

In these experiments observe the small variety in the reactions at first. What is the inference?

(d). The test should be repeated daily for a few days noting the progress in discrimination of sounds and the emotional concomitants. (e). At the age of about three weeks, test for æsthetic sense in connection with sound.[4] An air played softly upon a violin or even sung softly will serve for test.

4. *Vision.*[5] Make tests as soon as the eyes begin to open. (a). Bring the rats into a strong light. (b). Strike the hand across the field of vision an inch or two in front of the eyes.

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[1] Mills, W.: *Loc. cit.*, p. 176, 177. (I have not been able to confirm Prof. Mills's experiment with respect to rats. Cf. Morgan, C. L.: *Loc. cit.*, p. 117.)

[2] "Rats are enticed by certain essential oils." Darwin: Descent of Man, p. 530.

[3] Mills, W.: *Loc cit.*

[4] Anecdotes of rats and mice being fascinated by music are so frequent and so well authenticated that this experiment is of peculiar interest. Cf. Weir, Dr. James: The Dawn of Reason, p. 116.

[5] It should be remembered that vision is the least efficient of the white rat's senses. A comparison should be made between the importance of vision and the importance of smell and hearing in the development of the young rats.

What effect in each case? Can you get a winking reflex without touching the eyes?

The experiment upon vision will probably be unprofitable after four or five days, except experiments for the determination of the distance at which the rats can see objects. These may be made at intervals as long as the study continues. These determinations may be made roughly by moving an unfamiliar object in front of the cage, carefully excluding all sound.

5. Observations of the common activities of the rats will yield information in regard to tactual and kinæsthetic sensations, and the sense of equilibrium.

INSTINCTIVE ACTIVITIES. After the eyes and ears are open, observe the gradual disappearance of some activities, the progressive perfection of others, and the appearance of still others.

A. *Vocal.* Even casual observations will show the diminution of vocal activity.

B. *Motor.* 1. Note the slow degeneration of the sucking instinct. 2. Orientation, climbing and washing are rapidly perfected. 3. New activities appear, 17th to 21st days. (a). Gnawing. They nibble at one's fingers, at food, and as early as the 21st day I have seen them gnawing a stick. (b). Digging. (c). Play activities — running, jumping, mock fighting, etc. They may frequently be seen licking each other. It is not apparent whether this is in play or whether they are searching for vermin.

At the end of four or five weeks the student should again "take account of stock" and catalogue the psychic outfit of his subjects. As all our knowledge of the animal mind is inferential, the same observations will serve as basis for conclusions as to instinct, general intelligence and emotion in the rat. For example, the constant investigations of the waking rat will declare his curiosity. The eager expectancy displayed at the usual feeding time,[1] especially when they hear the rattle of the food, is evidence of memory. Fear is apparent at every unusual noise.

[1] Rats should be fed in the afternoon.

II.

Suggestions for Experimental Study of Intelligence.

The preceding study of the young rats will have brought out the rat character sufficiently to warrant the setting of a good many tasks. For example: hunger, sociability, and curiosity may safely be appealed to as motives for the performance of tasks; climbing, digging, and gnawing are patently instinctive and persistent activities.[1]

Two practical suggestions for apparatus are appended. In each case aptness for learning, imitation, and memory may be tested. The rats should be at least six or seven weeks old.

1. The apparatus consists merely of an ordinary squirrel revolver. A revolver 10 inches in diameter and one foot long can be used in the cage described above, and it is better to perform the experiments in their accustomed place.

(a). Keeping the door of the revolver open, note the time required for the rats to learn to run the revolver.[2]

(b). After the rats have learned this lesson, a test of imitation may be made by introducing one or two uninitiated rats into the cage. The difference in time required to learn the lesson may be taken as a rough measure of imitation.

(c). Furthermore memory may be tested by removing the drum for a time and noting the results upon its return.

This experiment may be variously complicated. For example, after the rats have learned to run the revolver, the door-way may be closed with a spring door such as is described in connection with the next piece of apparatus.[3]

2. Two pieces of apparatus. In both cases the motive appealed to is hunger. The activity in one case is digging; in the other, gnawing.

(a). Exp. box 1. A box[4] 7 inches square and 6 inches high; sides of wire mesh, ¼ inch mesh; top, glass; bottom, wood. At one side of bottom, a hole 3½ by 2 inches is cut. Two strips of wood 1½ inches thick tacked to the bottom raise the box above the floor of the cage. Sand and sawdust are banked about the box just above the level of the floor. Food

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[1]This enumeration is merely a suggestion; it is not intended to cover the field.

[2]Other interesting things will be observed: *e. g.*, if there is any straw or litter in the cage, they are very likely to carry it into the revolver and make their nest there.

[3]In all these experiments the experimenter must be prepared for individual variations.

[4]The apparatus and the method is more fully described by Dr. L. W. Kline, *Am. Jour. Psychology*, Vol. X, No. 2, p. 277. The diary of a few days' experimentation is given.

of some kind[1] is placed in the box and the top fastened down. At the usual feeding time, Exp. box 1 is placed in the cage and banked up as described. There is nothing to mark the place of entrance. This experiment should be repeated daily till the lesson is completely learned, so that the rats go at once to the right place and dig into the box.[2]

(b). Exp. box 2. The same as Exp. box 1, except that the floor is solid and the entrance is on one side. The entrance is an opening, 2½ inches square. This opening is provided with an inward swinging door of sheet zinc, hung from the top. The door is attached by a spring[3] (an ordinary rubber band) to the top of the cage, so that when free it is held open. The door is held closed by means of narrow strips of stout paper stuck, with sealing wax, to the door and the lower edge of the box. Admission to the food within can be attained only by biting, pulling or scratching off the paper. This experiment, too, should be repeated daily until the habit of getting the food by removing the papers is formed.

The two experiments yield the same results in regard to the determination of instinct, intelligence, and habit.[4] The two should be carried on contemporaneously with two pairs of rats. Some interesting comparisons will in the form of discrimination be apparent.

A further study of intelligence may be made, after the two pairs have mastered their lessons, by interchanging the boxes.

After this new task has been performed, the problem may be complicated still more by alternating the boxes at unequal intervals. If it is desired to test even further the adaptability of the rat, other complications or variations may be devised.

Careful analysis of these experiments will reveal the parts played by the different psychic elements: the instinct feeling of hunger (and curiosity too, perhaps,), the instinctive activities employed, recognition, memory—these all combining to form complex associations.

The Cat.

"The cat seems to be a much more intelligent animal than is often supposed."—*Mivart.*

"Indeed no greater contrast in table manners can be observed anywhere than when we turn from the kennel or the pig sty and watch the dainty way in which a cat takes its meals."—*Robinson.*

"In will-power, and ability to maintain an independent existence the cat is superior to the dog."—*Mills.*

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[1] I use nothing but dog biscuit. The rats must not be over fed.

[2] Not more than two rats should be set to this task at once.

[3] A small hook soldered to the lower part of the door serves to attach the spring to the door.

[4] Kline, L. W.: *Loc. cit.*, p. 279.

A psychological study of the cat,[1] or allied species, will be more profitable and certainly more pleasant to both student and cat if the former bears in mind the dominant cat traits: She is independent of man from a vegetative standpoint; self-willed, will not brook restraint; she is slow to forget an injury and often resents it; enjoys kind treatment; she is for the most part solitary in her habits.

The senses, instinctive activities, the emotions, the formation of habits, and the growth of intelligence constitute the essential material for observation and investigation.

The *order* in which the senses develop, and likewise the order and the conditions under which the instinctive movements and the expression of the emotions occur, should first engage the attention, and that, too, not later than the second day.[2]

Sense of Smell. Cheese, meat, warm milk, the hands after being rubbed over a dog, after handling mice, carbolic acid, etc., may be presented as objects of smell. Can you distinguish between the act of sensing and the motor reactions?

Sense of Taste. Solutions of sugar, salt, and aloes may be applied to the tongue by means of a feather or camel's hair brush. Milk, vinegar, and meat juice may be similarly applied.

Touch. Reaction to the sense of touch may be solicited by touching the sole of the forepaw, the mouth, inner surface of the nostrils and the ear with a broom straw, or knitting needle.

Temperature. Heat an iron rod to an uncomfortable degree to the human skin (not hot enough to burn) and place it against the sole of the kitten's foot.

Pain. Pinch different parts with forceps or fingers—note the *latent* time before the response. Does the latent time shorten with age?

Sense of Support.[3] (a). Uneasiness manifested by cries, and gripping the supporting surface vigorously with its claws, when it crawls to the edge of the same, is interpreted as a response to a disturbance of the sense of support.[4] If convenient make the same experiment with a turtle, a puppy, an ant, a slug, a chick. (b). Place the kitten on a board 12 x 14

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[1] Brehm: Thiereleben (Saügethiere, Vol. I, pp. 461-480.); J. Hampden Porter's Wild Beasts, pp. 76, 305, contains many significant observations on the habits and traits of Felidæ.

[2] Prof. Wesley Mills is the first scientist to have observed daily the psychic development of the cat from birth to maturity. Many of the above suggestions are founded on Prof. Mills's work. See also Bernard Perez: Mes Deux Chats; Fragment de Psychologie Comparée, pp. 39-78. Paris, 1881.

[3] See literature under Rat.

[4] Prof. Mills says: "This seems to me as fundamental as anything that is to be found in animal psychology."

inches, the sagittal axis coinciding with the length of the board. Tip the board slowly by raising one side until the kitten perceives the new position. Tip the forward end in the same way, then the rear end—note the angle that the board makes with the horizon in each of the positions.[1]

Reactions to Rotation. Place the kitten on a small rotation table—head toward the periphery. Turn the table at a moderate rate through one rotation—note the direction of the *first* movement after the table stops.

Hissing.[2] This mode of expressing a certain group of emotions is natural only to the *Felidæ*, *Reptilia*, and a few birds. What stimulus provoked the first hissing sound. How many kinds of hissing sounds can you detect in the kitten? Note the same points with regard to spitting.

Tail and Ear Movements.[3] The movements of these pendant organs are for the most part instinctive, though in the case of the ear they would seem to be more of the nature of a reflex. Their *quivering* motion is a curious phenomenon.

Sight. Eyes open about eighth day — note shape, color, the distance at which objects are recognized, when the kitten first follows a moving object by turning the head and by rolling the eyes.

Special directions for observation and experimentation on the kitten after the tenth day are not only useless but a positive hindrance. No two observers are likely to surround the young cat with the same environment and conditions; therefore, in the matters of habit and intelligence, each place will have its own special problems. But the appearance of instincts and emotions peculiar to the cat will occur under all favorable conditions, so that it may be helpful to indicate what to expect or look for as the psychic life of the cat unfolds. Look then for the *first* appearance of spitting, hissing, making its toilet,[4] playing with inanimate objects,[5] chasing moving objects, stretching and yawning, especially after a nap or leaving its nest, enjoying being stroked, setting claws into upright objects, tree-climbing, purring, crouching, "lying in wait," bowing the back in rage, playing "with real living prey," *e. g.*, a mouse,[6] playing "with living mock prey,"[7] *e. g.*, its mother or another

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[1] "(b)" is not an experiment to test the sense of support, but rather that of "position."

[2] For a probable origin of hissing and tail wagging, see Louis Robinson, "Wild Traits in Tame Animals." London, 1897, pp. 228-264.

[3] Ingersoll, E.: Wild Neighbors. See chap. "The service of Tails."

[4] Robinson, Louis: *Loc. cit.*, pp. 262-264.

[5] Robinson, Louis: *Loc. cit.*, pp. 228-229.

[6] Groos, Karl: The Play of Animals, pp. 121 and 130.

[7] Mills, Wesley: *Loc. cit.*, p. 196.

kitten. How many of these activities can you account for? What is their significance in the economy of cat life? A study in the formation of associations and their consequent habits, may most naturally begin (a) by observing the kitten in learning its name. Make a record of the number of times the name is uttered until it is recognized by the kitten. While teaching it, the name should be used judiciously, and always in immediate connection with a pleasurable reward, *e. g.*, food, stroking, giving it a play object to which it has become attached.

(b). Select from among its play activities, one that the cat may be readily induced to repeat (this the observer must decide), then create conditions that will call forth a second one that has a pleasure giving or satisfying effect. Note the number of times necessary to create the new condition that shall call forth the second act without hesitation. The following account of an actual case will illustrate the point. After the young cat had become accustomed to play with a ball, a long string was attached to the ball by which it was withrawn gently from the cat and dropped into a work-basket. The cat saw the whole performance and immediately took the ball from the basket and continued the play for a few minutes when the ball was jerked away and dropped into the basket with the quickest possible despatch. After two experiences, *i. e.*, at the third time the ball was jerked away, the cat went directly to the basket. The experiment may be varied—basket moved before the ball is jerked into it, a different basket used, etc.

Under this head would come teaching[1] some of the well known

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[1] A radically different method for studying associative processes from those given in (a) and (b) has been used by Dr. Thorndike. (Thorndike, E. L.: Animal Intelligence, p. 6. New York, 1898.) "It was merely to put animals when hungry in enclosure from which they could escape by some simple act, such as pulling at a loop of cord, pressing a lever, or stepping on a platform. . . . The animal was put in the enclosure, food was left outside in sight, and his actions observed. Besides recording his general behavior, special notice was taken of how he succeeded in doing the necessary act, and a record was kept of the time that he was in the box before performing the successful pull, or clawing, or bite. This was repeated until the animal had formed a perfect association between the sense impression of the interior of that box and the impulse leading to the successful movement." I recommend that the food be put *in the box* and the animal on the *outside*, free, unhampered, and that the several tasks set by Dr. Thorndike for the animal to do in order to escape be accordingly transferred to the outside of the boxes. I have found this method to work admirably well with the white rat, and the cat. See *Am. Jour. of Psychology*, 1899, Vol. X, pp. 277–279. The time required to perform each experiment, and particularly just how it is done, and whether or not experience facilitates the execution of the task, are among the essential items to be noted.

tricks, *e. g.*, rolling over, jumping through the hands, "begging" in upright position, shaking hands, etc.

Full notes are always valuable. While teaching them a task, the notes should be made as near as possible *at the time* of the experiment. It is highly important, too, that every circumstance attending the cat's first successful effort in doing a set task be carefully noted. If convenient, photographs should be taken; and especially of attitudes expressive of emotions that are usually so difficult to describe.